Comparative study of compressive strength of concrete under different compactive efforts.

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Abstract

Standard cubes and cylinder tests are generally performed to determine compressive strength of concrete according to standard codes. In the tests performed on various samples it is checked that the fresh concrete are properly compacted. Whereas, compaction received by concrete structures and standard specimens may be different at site. In achieving maximum compressive strength of moist-cured concrete water-to-cement ratio and degree of compaction plays an important role. The void spaces in concrete if not filled by proper compaction, significantly reduces the compressive strength, that may effect the durability of concrete members. The effect of compaction on concrete strength determined by rebound hammer, ultrasonic pulse velocity, and pull-out techniques as well as core test were examined, in this experimental work. For performing the tests, a concrete mixture with ordinary Portland cement, crushed limestone aggregate, water, and a plasticizing admixture were used. Cubes and beams were casted by the prepared concrete mixture. Compaction of beams were done in 3 different levels. It is found in results that compaction affects drastically the rebound number, ultrasonic pulse velocity, pull-out force, and core strength.

Keywords: Concrete, Compaction, Durability, Testing, Strength

Introduction

Most widely used construction material in civil engineering construction industry, is concrete, it is produced by mixing together cement, coarse aggregate, fine aggregates, water, and admixture if required. Compressive strength test is the common test applied mostly on concrete specimens for determining various characteristics, because it is easy to perform and also because other characteristics of concrete can be related to its strength, mainly but, because of compressive strength is used in structural design for various structures [4]. Compressive strength of concrete cast in structures is generally determined by standard cube or cylinder tests are generally performed to determine compressive strength of concrete at different durations. These standard tests that are conducted on concrete specimens that represent the quality of concrete and they should be in full compaction without voids. Whereas , compaction received by concrete structures and standard specimens in the field may be different condition. Various tests such as destructive, non-destructive, and partially destructive tests were performed in order to determine concrete strength in structures. The prediction of the test results is very difficult as number of factors affects the results such as concrete mix proportions, properties of ingredients, curing conditions and degree of compaction of concrete. In this experimental investigation, the compaction effect received by concrete on the strength is determined by standard, destructive, non-destructive, and partially destructive techniques were examined. The moist-cured concrete strength mainly depends on the water-cement (w/c) ratio and degree of compaction. In fully concrete compacted, compressive strength is inversely proportional to water-cement ratio of mixture. In practice, concrete may contain some voids due to improper compaction and the presence of such imperfections in concrete reduces its compressive strength or load bearing capacity. It can also be said that, the strength of improper compacted concrete is very much lower than that of fully properly compacted concrete, with low w/c ratios. For instance, the concrete compressive strength reduces nearly 30% when concrete sample has 5% voids [4]. Hence, the aim of proper compaction is to remove entrapped air from the concrete, and it is found that it is possible to remove 3% air from voids by vibrating concrete just for 15 seconds duration [4, 8]. Most concrete is consolidated by internal vibrators. The energy is provided by the head of the vibrator nozzle, that vibrates with electric energy or with diesel motors. By vibration solid particles gets excited in the concrete mix, causing fresh concrete to flow. Momentum is transferred through particle to particle collisions. Due to vibration effect, mortar in concrete, then begins to flow between the voids in between coarser aggregates. In this experimental work, some beams were compacted by internal vibration, some were compacted by rod tamping , and remaining beams were not compacted. The compaction effect on the compressive strength were determined, by non-destructive, partially-destructive, and destructive testing techniques and, were discussed.

Experimental Analysis

In this experimental study, a concrete mixture was prepared by Ordinary Portland cement, crushed limestone and sand as coarse and fine aggregates respectively, water, and a plasticizer. The concrete mixture proportions were tabulated in Table 1.

Table 1. Concrete Mixture Proportions

S.No	Ingredients	-	Quantity
1	Cement, kg/m^3	-	500
2	Water, kg/m^3	-	210
3	Coarse aggregate , kg/m^3	-	1083
4	Fine aggregate, kg/m^3	-	630
5	Plasticizer kg/m^3	-	6

By using this concrete mixture,150mm cube size and 250mmx300mmx600mm size beam specimens were casted. Compaction of beam specimens were compacted in three different levels such that some of the beams were compacted by internal vibration by vibrators, some of the beam were compacted by rod tamping, and remaining beams were not compacted. The moulded beams were moist-cured in the laboratory until they are tested. Standard cube specimens were also fully compacted by vibrators and were also moist-cured till they are tested. After curing for desired duration, Rebound hammer, UPV, pull-out, and core tests were conducted on beam specimens that were compacted in different levels. In this test using rebound hammer, a type N-rebound hammer impact energy of 0.225 were employed. In each measurement, 12 readings were taken and then it is averaged. The hammer was applied horizontally and three beams were tested for each different compaction levels. In UPV tests, measurements were carried out through 9 paths by direct transmission and then averaged. 3 beams were tested for each compaction degree. In pull-out tests, a special equipment including a hydraulic jack, a reaction ring and connection hoses were used. The metal inserts of the test were inserted to the formwork before concrete casting. The pull-out forces are the average of six results. The cores of 144, 94, 69, and 46 mm diameter were removed by drilling in the perpendicular direction to the direction of concrete casting. The length-to-diameter ratios of the core specimens were 1.0 after capping. The specimens were capped with high early strength cement paste. The compressive strength test on cores and cubes were conducted by fully automatic machine and the rate of load application on concrete specimen was 0.25 MPa/s

Results And Discussions

The comparative compaction effect on rebound number, UPV, and pull-out force measured on beam specimens are shown in Figure 1-3, respectively. Testing results show that rebound numbers measured on concrete beams compacted by vibrator were found to be higher as compared to those compacted by rod tamping and to those produced without compaction of concrete, irrespective of age of concrete. As it was found that, rebound numbers were measured as 34.3, 32.4, and 32.1 for concrete beams that were compacted by vibrators with nozzle, also that were compacted by rod, and rebound numbers that were produced without compaction, respectively at 28-days age. Practically test results have shown that UPV values measured on concrete beams compacted by vibrators with nozzle were higher as compared to those measured on concrete beams that were compacted by rod tamping and those measured on concrete beams produced, without any compaction. For instance, the average UPV values were found to be 4.77, 4.65, and 4.63 km/s for concrete beams compacted by vibrators, for concrete beams compacted by rod tamping, and for

concrete beams produced without compaction, respectively. Figure 4 shows that the pull-out forces measured on beams compacted by vibrator were found to be higher than those measured on beams compacted by rod tamping and those measured on concrete beams casted without compaction. For example, the pull-out forces were measured as 39.8, 30.4, and 27.9 kN for concrete beams consolidated by vibrator, for concrete beams compacted by rod tamping, and for concrete beams produced without compaction.

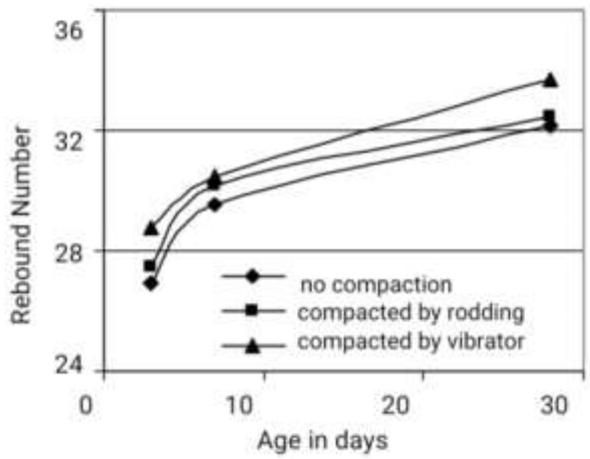

Figure 1. Compaction effect on rebound number.

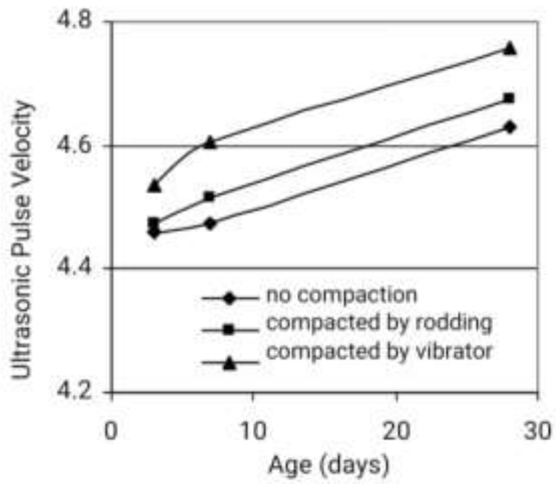

Figure 2. Compaction effect on UPV.

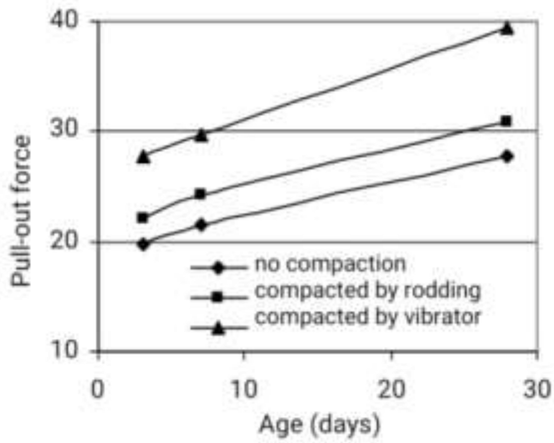

Figure 3. Compaction effect of Pull-out force test results.

Figure 4 shows the ratio of core to cube strengths. It was found that the ratio of strength of 94 mm diameter cores, having l/d ratio of 1 to that of 15 cm cube was about 0.9 for cores removed from concrete beams, compacted by vibrators. These ratios were near 0.82 and 0.8 for cores removed from beams compacted by rod and for cores removed from beams cast without any compaction, respectively. The effect of compaction on fresh concrete, core strength can be seen in Figure 5, in which it shows relative core strengths. Practically 0.89 was the ratio of strength of cores removed from concrete beams produced without compaction to that of cores removed from beams compacted by vibrator, and 0.91 was the ratio for concrete beams compacted by rod (94 mm cores).

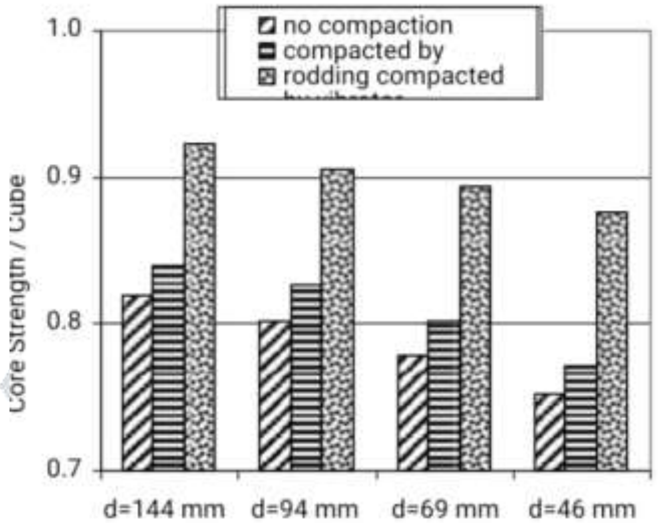

Figure 4. Core to cube strengths ratios.

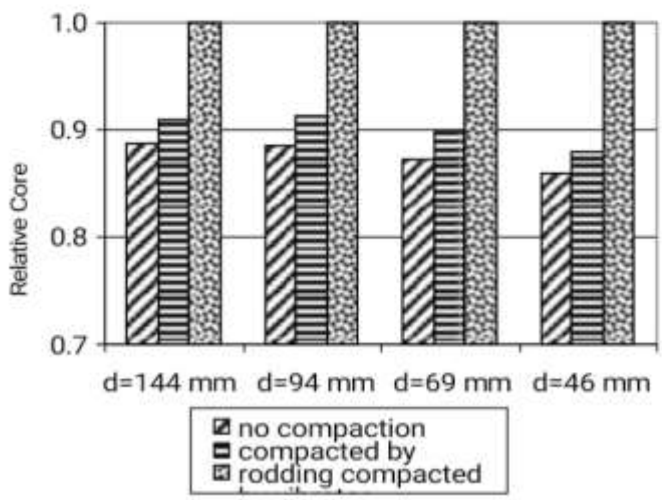

Figure 5. Compaction effect on concrete core strength.

Conclusion

The following points may be drawn from the present investigation;

It is seen that rebound numbers measured on concrete beams, compacted by vibrator were found to be higher, than those compacted by rod and those produced without compaction.

UPV values measured on concrete beams compacted by vibrator were higher as compared to measured on concrete beams compacted by rod and those measured on concrete beams produced without compaction process.

Pull-out forces on beams, compacted by vibrator were measured to be higher than those measured on beams, that were compacted by rod and those measured on beams that were casted without compaction.

Core-to-cube strength ratios were 0.89, 0.85, and 0.81 for beam specimens of concrete compacted by vibrators internal vibrators, for specimens compacted by rod, and for specimens produced without compaction, respectively.

Ratio of strength of cores drilled from concrete beams cast without compaction to that of cores removed from concrete beams compacted by vibrator was found to be 0.90.

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